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**Doty**

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(54) **DECREASING POWER REQUIREMENTS  
FOR AN OUTPUT SIGNAL BASED ON  
PERSISTENCE OF PERCEPTION  
CHARACTERISTICS**

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**H04N 5/14** (2006.01)

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CPC ..... **H04N 5/20** (2013.01); **H04N 5/148**  
(2013.01); **H04N 5/265** (2013.01)

(58) **Field of Classification Search**  
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USPC ..... 348/180, 571, 588, 441, 607; 702/71,  
702/73, 57

See application file for complete search history.

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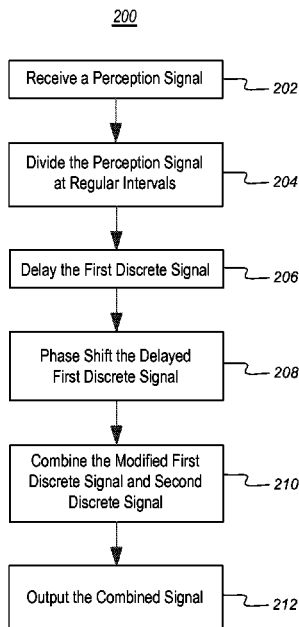
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L. Call

(57) **ABSTRACT**

A system for decreasing output power required to produce an output signal based on persistence of perception characteristics. The system includes a circuit configured to receive a perception signal at an input. The circuit is also configured to output a portion of the input perception signal when the circuit is receiving power output a zero amplitude signal when the circuit is not receiving power. The system also includes a switch configured to provide power to the circuit for a first interval of time and cut power to the circuit for a second interval of time contiguous to the first interval of time.

**19 Claims, 3 Drawing Sheets**



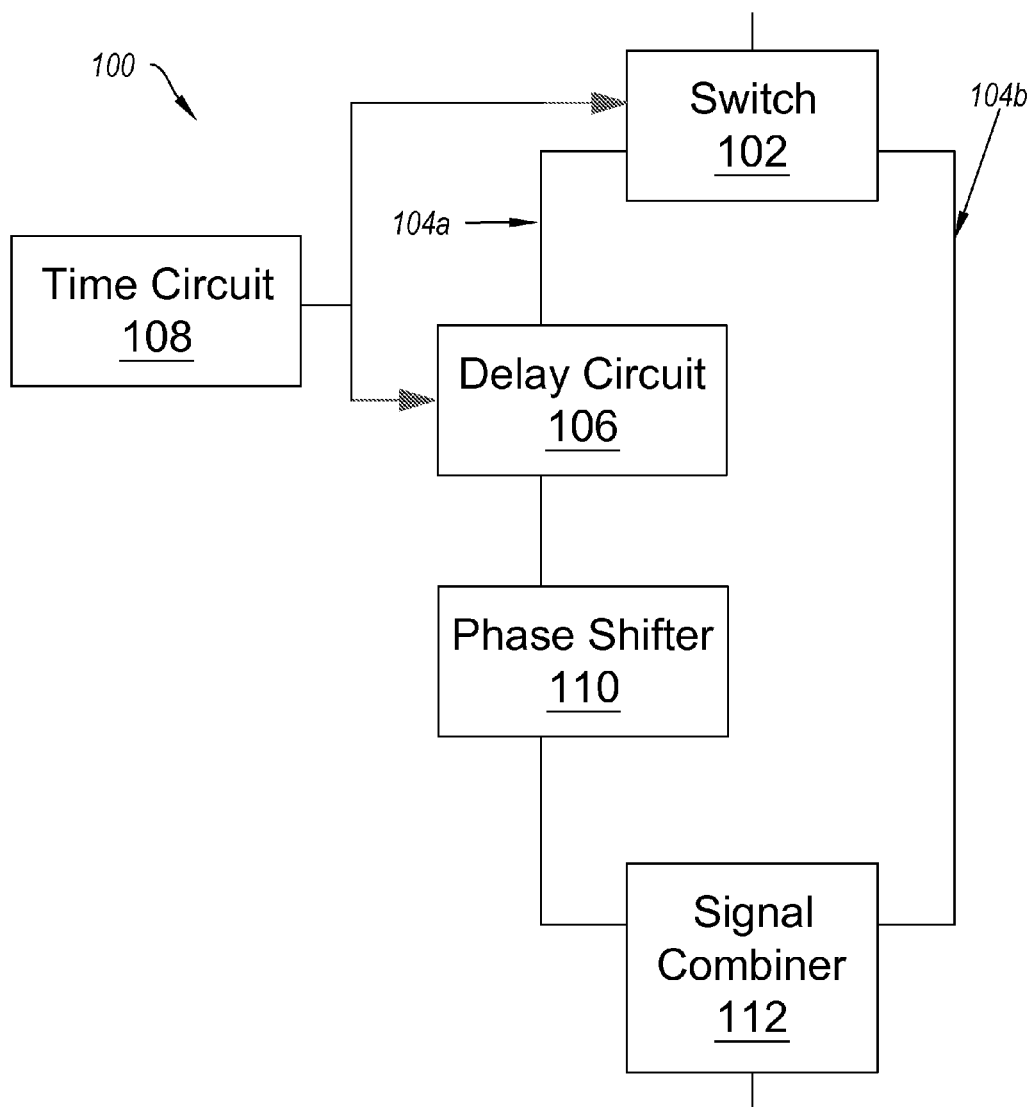
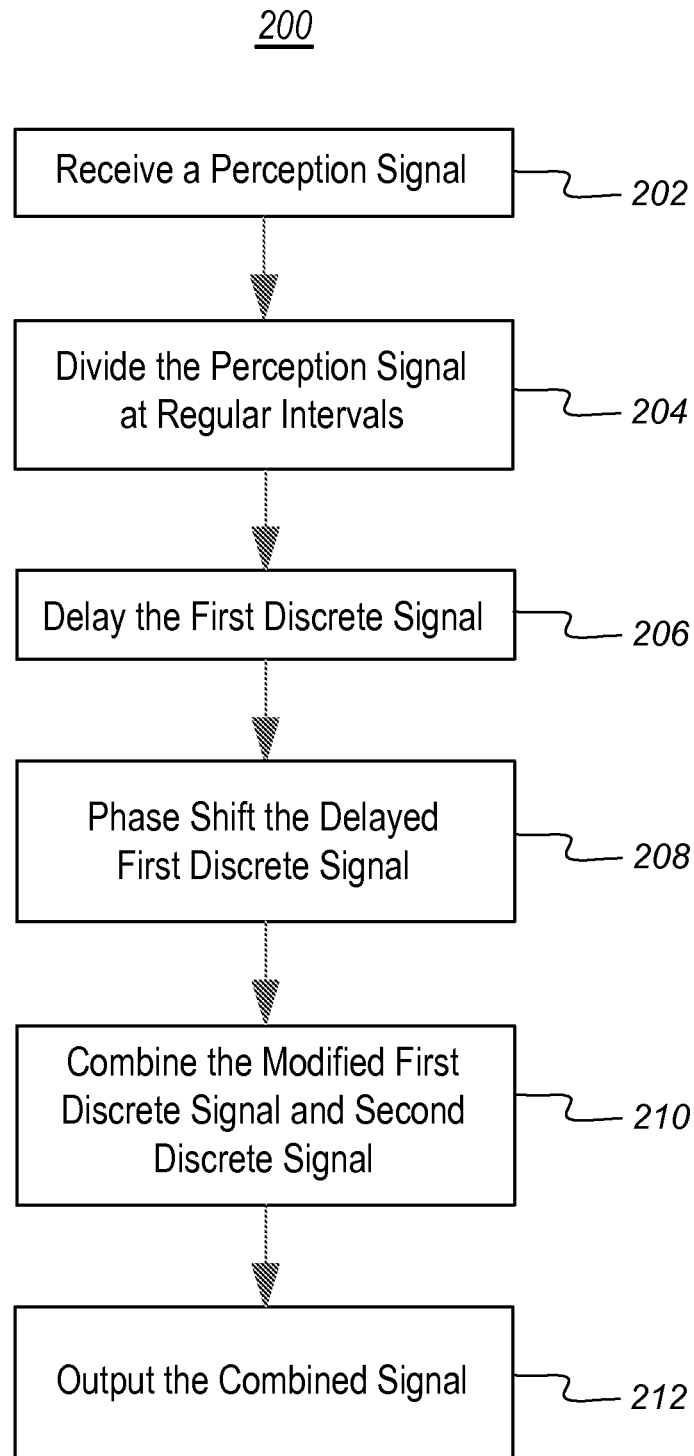


FIG. 1

*FIG. 2*

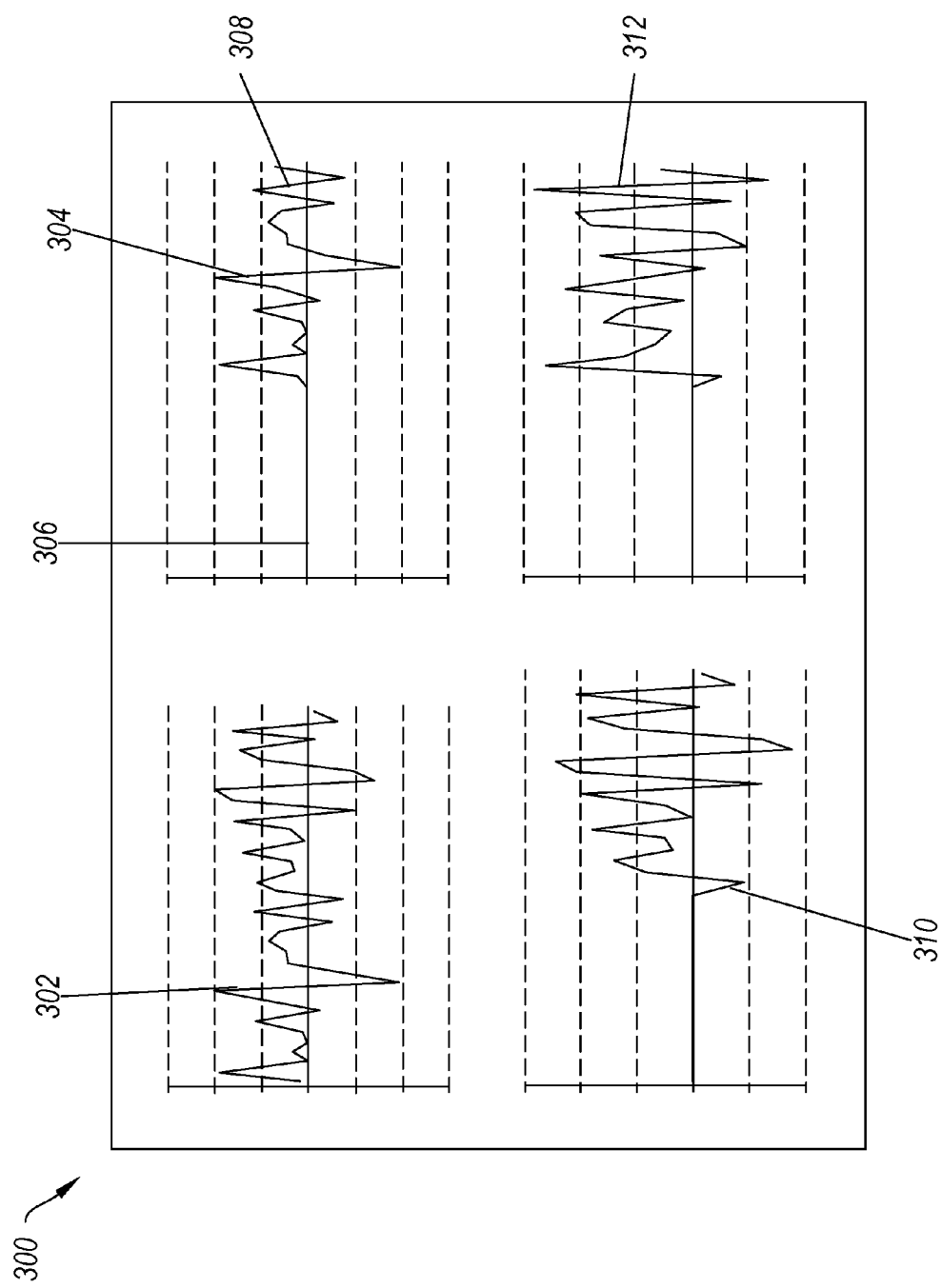


FIG. 3

1

## DECREASING POWER REQUIREMENTS FOR AN OUTPUT SIGNAL BASED ON PERSISTENCE OF PERCEPTION CHARACTERISTICS

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of and priority to U.S. Non-Provisional patent application Ser. No. 13/938,060 filed on Jul. 9, 2013, which application is incorporated herein by reference in its entirety.

### BACKGROUND OF THE INVENTION

Human perception tends to occur in discrete intervals. For example, video typically includes still pictures that are shown for a very limited period of time before changing to the next still image. Viewed independently, the pictures appear very “jerky.” However, viewed at a fast enough speed our brains convert the images into a video, rather than a series of images. This is true of other senses as well. For example, human hearing occurs in discrete intervals. Thus, gaps in sound below a certain duration are not perceived by our brains.

Typically, hearing devices and other hearing devices are all designed to amplify audio signals work in a similar manner. They receive an audio signal, convert it to an electronic signal, amplify the electronic signal then convert the amplified signal back to an audio signal using a speaker or other device. The speaker may be located near the user’s ear to minimize the power needed and to prevent the amplification from disturbing others near the user.

However, this process leads to some drawbacks. For example, the amplification requires power input to the signal. Amplification of the signal increases the noise level of the signal. Likewise, the conversion of the audio signal to an electronic signal and vice versa both introduce further noise into the final audio signal. All of these sources of noise result in the output audio signal being of lower quality than the original signal.

Moreover, the same problems occur in electronic signals that will be converted into an audio signal. For example, in speakers and headphones, the electronic signal can be amplified prior to reaching the speaker. The speaker will then broadcast a louder signal to the user. However, the speaker may be limited in the volume of audio that it will produce. Additionally, the amplification of noise remains a problem.

Likewise, visual signals can be increased in power or “brightness.” However, the amplification requires additional power and introduces noise which makes viewing difficult. Thus, amplification using conventional methods sacrifices quality. This tradeoff may be worth it depending on the application.

Accordingly, there is a need in the art for a device that can amplify a perception (audio or visual) signal without degrading the signal quality. In addition, there is a need in the art for the device to have low power requirements. Further, there is a need in the art for the device to avoid, to the extent possible, introducing noise into the perception signal.

### BRIEF SUMMARY OF SOME EXAMPLE EMBODIMENTS

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential characteristics of the

2

claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

One example embodiment includes a system for decreasing output power required to produce an output signal based on persistence of perception characteristics. The system includes a circuit configured to receive a perception signal at an input. The circuit is also configured to output a portion of the input perception signal when the circuit is receiving power output a zero amplitude signal when the circuit is not receiving power. The system also includes a switch configured to provide power to the circuit for a first interval of time and cut power to the circuit for a second interval of time contiguous to the first interval of time.

One example embodiment includes a system for decreasing output power required to produce an output signal based on persistence of perception characteristics. The system includes a circuit configured to receive a perception signal at an input. The circuit is also configured to output a portion of the input perception signal when the circuit is receiving power output a zero amplitude signal when the circuit is not receiving power. The system also includes a switch configured to provide power to the circuit for a first interval of time and cut power to the circuit for a second interval of time contiguous to the first interval of time. The first interval of time is equal to or shorter than the threshold for persistence of perception and the second interval of time is equal to or shorter than the threshold for persistence of perception.

Another example embodiment includes a method of decreasing output power required to produce an output signal based on persistence of perception characteristics. The method includes receiving a perception signal. The method also includes dividing the perception signal at predetermined intervals to produce for a first interval of time, an output equal in amplitude to the perception signal and for a second interval of time, an output with zero amplitude. The first interval of time is equal to or shorter than the threshold for persistence of perception and the second interval of time is equal to or shorter than the threshold for persistence of perception.

These and other objects and features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

### BRIEF DESCRIPTION OF THE DRAWINGS

To further clarify various aspects of some example embodiments of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It is appreciated that these drawings depict only illustrated embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

FIG. 1 illustrates an example of a system for increasing perceived signal strength;

FIG. 2 is a flow chart illustrating a method of doubling perceived signal strength; and

FIG. 3 illustrates an example of a waveform as it is modified.

### DETAILED DESCRIPTION OF SOME EXAMPLE EMBODIMENTS

Reference will now be made to the figures wherein like structures will be provided with like reference designations. It

is understood that the figures are diagrammatic and schematic representations of some embodiments of the invention, and are not limiting of the present invention, nor are they necessarily drawn to scale.

FIG. 1 illustrates an example of a system **100** for increasing perceived signal strength. The system **100** can be configured to utilize human's persistence of perception characteristics. Persistence of perception is the inability of the human senses to respond to distinct perceptions within a specified time frame. For example, it may be that the brain, the sensing organs (e.g., ears, eyes, etc.) or both are unable to process a perception signal within a certain period of time, thus the perception signal is perceived to last the entire "processing time." Persistence of perception includes persistence of vision, which allows motion pictures or television to be perceived as a continuous signal, rather than individual frames. For example, for movies a standard projection speed of 24 frames, or still pictures, per second was adopted. 24 frames per second translates to a frequency of approximately 0.042 seconds. Thus, the frequency must be lower than approximately 0.05 seconds for persistence of vision to convert flickering images into a moving visual signal. This was because a viewer stopped seeing individual frames at this speed and instead perceived a continuous motion picture. One of skill in the art will appreciate that a perception signal as used herein can refer to any signal which can be perceived directly by a human or that can be converted to a signal that can be perceived directly for a human. For example, a perception signal can include a video or electronic or EM signal that is intended to be converted to a video or an audio signal or electronic or EM signal that is intended to be converted to an audio signal. As used in the specification and the claims, the term approximately shall mean that the value is within 10% of the stated value, unless otherwise specified.

Persistence of perception also includes perception of hearing. The length of persistence of hearing depends on a number of factors including amplitude, pitch and whether the input is continuous sine waves or impulsive signals. However, in most cases, at about 40 Hz, a beat is heard as individual beats. As the frequency increases above about 50 Hz it is perceived by the human ear as a hum, or tone, rather than individual beats. In almost all cases when the frequency goes above 60 Hz the beats are heard as a hum, regardless of other factors. Therefore, the frequency above which persistence of hearing prevents hearing of a sine wave signal of individual beats can be approximated at 55 Hz. When the ear receives input in the form of impulsive signals the persistence of hearing becomes much shorter—approximately 0.006 seconds.

Persistence of hearing also means that individual pauses cannot be heard. I.e., if one were to take a sound signal and remove portions of the continuous sine wave signal which have a duration of less than 0.018 seconds (which corresponds to a frequency of 55 Hz) the removal could not be perceived by a human ear. I.e., the sound signal would sound to a human ear as if the sound signal was unaltered. These characteristics can be taken advantage of to increase perceived signal strength without resulting in noticeable degradation of a sound signal.

This principle is illustrated by carefully designed experiments wherein Morse code was presented so as to determine the highest speed that could be perceived by the ear. These tests indicated that Persistence of Hearing lasts for approximately 0.006 seconds when impulsive sound signals are presented to the ear.

One of skill in the art will appreciate that a sound signal as used herein can refer to any signal which can be heard directly by a human or that can be converted to a signal that can be

heard directly by a human. For example, a sound signal can include an audio signal, a radio signal, an electronic signal to be input into a speaker, or any other desired signal.

FIG. 1 shows that the system **100** can include a switch **102**. The switch **102** can be configured to receive an input perception signal and divide the signal into discrete signals at predetermined intervals. For example, if the interval is 0.006 seconds, then every 0.006 seconds the switch will separate the input signal into discrete signals and if the interval is 0.05 seconds, then every 0.05 seconds the switch will separate the input signal into discrete signals. An interval of 0.006 seconds can be critical to ensure that perception of hearing characteristics are used and that the user does not hear any disruption. Likewise an interval of 0.05 seconds can be critical to ensure that perception of vision characteristics are used and that the user does not see a disruption in the video signal.

FIG. 1 also shows that the system **100** can include a first signal path **104a** and a second signal path **104b** (collectively "signal paths **104**"). The first signal path **104a** can be configured to receive every other discrete signal produced by the switch with the other discrete signals received by the second signal path **104b**. For example, the first signal path **104a** can receive the first discrete signal, the second signal path **104b** can receive the second discrete signal, the first signal path **104a** can receive the third discrete signal, etc. The signal paths **104** can include any medium configured to transmit the discrete signals.

FIG. 1 further shows that the system **100** can include a delay circuit **106**. The delay circuit **106** can delay the first set of signals along the first signal path **104a**. The delay can be as close as possible to the time interval of each discrete signal. I.e., if the switch **102** divides the input signal into discrete signals of 0.006 seconds, the desired delay of the delay circuit is 0.006 seconds or if the switch **102** divides the input signal into discrete signals of 0.05 seconds, the desired delay of the delay circuit is 0.05 seconds. This will delay each signal so that it is as close as possible to the next discrete signal. I.e., the beginning of the first discrete signal will be delayed to match the beginning of the second discrete signal; the beginning of the third discrete signal will be delayed to match the beginning of the fourth discrete signal; etc. The delay circuit **106** can be adjustable to ensure correct syncing of the first discrete signal and the second discrete signal.

FIG. 1 additionally shows that the system **100** can include a time circuit **108**. The time circuit can allow the switch **102** and the delay circuit **106** to operate using the same clock signal. I.e., the switch **102** and the delay circuit **106** can both be controlled by the output of the time circuit **108**, ensuring that the time interval of the discrete signals is the same as the length of the delay. For example, the time circuit **108** can include a function generator, an oscillator or any other circuit producing a repeatable signal.

FIG. 1 moreover shows that the system **100** can include a phase shifter **110**. The phase shifter **110** can correct the phase of the delayed signal to match the phase of the undelayed signal or vice versa. I.e., the phase shifter **110** can ensure that the delayed first discrete signal matches the phase of the second discrete signal.

FIG. 1 also shows that the system **100** can include a signal combiner **112**. The signal combiner **112** can be configured to receive the delayed signal from the first signal path **104a** and the undelayed signal from the second signal path **104b** and combine the two signals. I.e., the first discrete signal was delayed in the delay circuit **106**, phase shifted in the phase shifter **110** then combined with the unchanged second discrete signal in the signal combiner **112**.

5

One of skill in the art will appreciate that the output signal from the signal combiner **112** will have effectively doubled the perceived signal strength. I.e., the power from the first time interval will be added to the power from the second time interval, doubling the perceived signal strength. In addition, because the empty gap produced is below the threshold for persistence of perception, the signal will be perceived as a single continuous signal. Because the perception signal does not change appreciably between discrete signals, the user will not perceive any distortions but will perceive a signal that has doubled in power.

FIG. 2 is a flow chart illustrating a method **200** of doubling perceived signal strength. In at least one implementation, the method **200** can be used in a system, such as the system **100** of FIG. 1. Therefore, the method **200** will be described, exemplarily, with reference to the system **100** of FIG. 1. Nevertheless, one of skill in the art can appreciate that the method **200** can be performed by a system other than the system **100** of FIG. 1.

FIG. 2 shows that the method **200** can include receiving **202** a perception signal. The perception signal can be received **202** using a microphone, a camera, a camcorder, or can be received before it is sent to an output device, such as a speaker or monitor. The perception signal can be an audio signal, a visual signal, an electrical signal, an electromagnetic signal or any other desired signal.

FIG. 2 also shows that the method **200** can include dividing **204** the perception signal at regular intervals to produce a first discrete signal and second discrete signal. In particular, the signal can be divided **204** such that the duration of the first discrete signal and the second discrete signal are the same as one another. One of skill in the art will understand that although ensuring that the duration of the first discrete signal and the second discrete signal is the exact same is impossible, as used herein the term “the same” means that the duration of the first discrete signal and the second discrete signal as are close to one another as possible or practical.

FIG. 2 further shows that the method **200** can include delaying **206** the first discrete signal. The first discrete signal **206** can be delayed the same amount of time as the duration of the first discrete signal such that the first discrete signal now begins at the same time as the second discrete signal begins. One of skill in the art will understand that delaying **206** the first discrete signal may not be necessary if the entire signal is present such as being stored electronically. However, if the signal is being received in real time, then the delay **206** may be necessary.

FIG. 2 additionally shows that the method **200** can include phase shifting **208** the delayed first discrete signal to produce a modified first discrete signal. Phase shifting **208** the first discrete signal can ensure that the first discrete signal and the second discrete signal are in phase with one another, which can reduce the perceived distortion of the signal. I.e., phase shifting **208** the first discrete signal can reduce distortion perceived by an observer.

FIG. 2 moreover shows that the method **200** can include combining **210** the first discrete signal and the second discrete signal. Combining **210** the first discrete signal and the second discrete signal doubles the perceived signal strength but does not require an addition of power. In particular, the human ear does not hear the first discrete signal and the second discrete signal as separate signals and the human eye does not see the first discrete signal and the second discrete signal as separate signals, therefore combining them results in unchanged perception in terms of the actual sound or visual input. However, the combined signals have a greater amplitude increasing the perceived volume or brightness.

6

FIG. 2 also shows that the method **200** can include outputting **212** the combined signal. The output **212** can be a visual signal or an audio signal that will be perceived by the user. Additionally or alternatively, the output **212** can include an electronic signal that will be output as an audio signal by an external device. For example, the output **212** can include sending the combined signal to a speaker or monitor, where the sound or video will be produced for the user.

One skilled in the art will appreciate that, for this and other processes and methods disclosed herein, the functions performed in the processes and methods may be implemented in differing order. Furthermore, the outlined steps and operations are only provided as examples, and some of the steps and operations may be optional, combined into fewer steps and operations, or expanded into additional steps and operations without detracting from the essence of the disclosed embodiments.

FIG. 3 illustrates an example of a waveform **300** as it is modified. The waveform **300** can be modified in order to take advantage of persistence of perception. I.e., the waveform **300** can be modified to increase the perceived signal strength without requiring additional power.

FIG. 3 shows that the waveform **300** can initially be an unmodified waveform **302**. The unmodified waveform **302** can include a perception signal, as described above. The unmodified waveform **302** can include portions before and after the portion shown; however, for illustrative purposes the waveform **302** can be used to show the modifications to the waveform **300** regardless on any signal that may be present before or after the waveform **302**.

FIG. 3 also shows that the waveform **300** can be used to create a first discrete waveform **304**. I.e., the waveform **302** after a first discrete signal is created, delayed and/or phase shifted to create the modified first discrete waveform **304**. For example, the first discrete waveform **304** can be the waveform that has passed through the first signal path **104a** of FIG. 1. The modified first discrete waveform **304** includes a first section **306** which includes no data or just noise and a second portion **308** which includes the first half of the data from the unmodified waveform **302**.

FIG. 3 further shows that the waveform **300** can be used to create a second discrete waveform **310**. The second discrete waveform **310** can be a portion of the original waveform **302** which remains unmodified after being separated from the first discrete waveform. For example, the second discrete waveform **310** can include the waveform which passed through the second signal path **104b** of FIG. 1.

FIG. 3 additionally shows that the modified first discrete waveform **304** and the second discrete waveform **310** can be combined to produce an output waveform **312**. The output waveform **312** can be perceived to be stronger than the original waveform **302** by an observer due to persistence of perception characteristics, as described above.

The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

1. A system for decreasing output power required to produce an output signal based on persistence of perception characteristics, the system comprising:

7

a circuit configured to:  
 receive a perception signal at an input; and  
 output a portion of the input perception signal when the  
 circuit is receiving power;  
 output a zero amplitude signal when the circuit is not  
 receiving power; and  
 a switch configured to:  
 provide power to the circuit for a first interval of time;  
 and  
 cut power to the circuit for a second interval of time  
 contiguous to the first interval of time.

2. The system of claim 1 further comprising a time circuit  
 configured to indicate the first interval of time to the switch.

3. The system of claim 2, wherein the time circuit is further  
 configured to indicate the second interval of time to the  
 switch.

4. The system of claim 1, wherein the first interval of time  
 is shorter than the threshold for perception of vision.

5. The system of claim 4, wherein the first interval of time  
 is shorter than 0.05 seconds.

6. The system of claim 1, wherein the second interval of  
 time is shorter than the threshold for perception of vision.

7. The system of claim 6, wherein the second interval of  
 time is shorter than 0.05 seconds.

8. The system of claim 1, wherein the first interval of time  
 is shorter than the threshold for perception of hearing.

9. The system of claim 8, wherein the second interval of  
 time is shorter than the threshold for perception of hearing.

10. A system for decreasing output power required to pro-  
 duce an output signal based on persistence of perception  
 characteristics, the system comprising:

a circuit configured to:  
 receive a perception signal at an input; and  
 output the input perception signal when the circuit is  
 receiving power;  
 output a zero amplitude signal regardless of the ampli-  
 tude of the input perception signal when the circuit is  
 not receiving power; and  
 a switch configured to:  
 provide power to the circuit for a first interval of time,  
 wherein the power allows the circuit to pass though  
 the input perception signal;  
 cut power to the circuit for a second interval of time  
 contiguous to the first interval of time, wherein the  
 lack of power ensures that the output of the circuit is  
 the zero amplitude signal; and

8

alternating between the first interval of time and the  
 second interval of time;  
 wherein the first interval of time is equal to or shorter than  
 the threshold for persistence of perception; and  
 wherein the second interval of time is equal to or shorter  
 than the threshold for persistence of perception.

11. The system of claim 10, wherein the perception signal  
 includes a visual signal.

12. The system of claim 10, wherein the perception signal  
 includes an electronic signal to be converted to a visual signal.

13. The system of claim 10 further comprising a monitor  
 configured to receive the output signal and output a visual  
 signal.

14. The system of claim 10, wherein the perception signal  
 includes an audio signal.

15. The system of claim 10, wherein the perception signal  
 includes an electronic signal to be converted to an audio  
 signal.

16. The system of claim 10 further comprising a speaker  
 configured to receive the output signal and output an audio  
 signal.

17. A method of decreasing output power required to pro-  
 duce an output signal based on persistence of perception  
 characteristics, the method comprising:  
 receiving a perception signal at a circuit;  
 supplying power to the circuit for a first interval of time;  
 and  
 removing power from the circuit from a second interval of  
 time, wherein the second interval of time is contiguous  
 to the first interval of time;  
 wherein supplying and removing power divides the per-  
 ception signal at predetermined intervals to produce:  
 for the first interval of time, an output equal in amplitude  
 to the perception signal; and  
 for the second interval of time, an output with zero  
 amplitude;  
 wherein the first interval of time is equal to or shorter than  
 the threshold for persistence of perception; and  
 wherein the second interval of time is equal to or shorter  
 than the threshold for persistence of perception.

18. The system of claim 17, wherein the first interval of  
 time is equal to or shorter than 0.05 seconds.

19. The system of claim 17, wherein the second interval of  
 time is equal to or shorter than 0.05 seconds.

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